

## Sub Name: PRINCIPLES OF FOOD ENGINEERING

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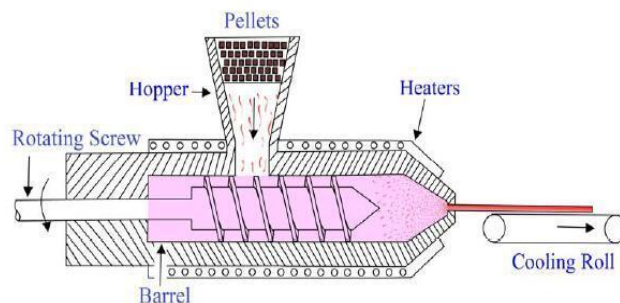
### What is Extrusion?

Extrusion technique is a process in food processing technology which combines several unit operations including mixing, cooking, kneading, shearing, shaping and forming. Food extrusion is a form of extrusion used in food processing. It is a process by which a set of mixed ingredients are forced through an opening in a perforated plate or die with a design specific to the food, and is then cut to a specified size by blades. The machine which forces the mix through the die is an extruder, and the mix is known as the extrudate. The extruder consists of a large, rotating screw tightly fitting within a stationary barrel, at the end of which is the die.

Extrusion cooking is a high-temperature short-time (HTST) process which reduces microbial contamination and inactivates enzymes. The main method of preservation of both hot- and cold-extruded foods is by the low water activity of the product (0.1–0.4), and for semi-moist products in particular, by the packaging materials that are used.

The principles of operation in extrusion are similar in all types: raw materials are fed into the extruder barrel and the screw(s) then convey the food along it. Further down the barrel, smaller flights restrict the volume and increase the resistance to movement of the food. As a result, it fills the barrel and the spaces between the screw flights and becomes compressed.

As it moves further along the barrel, the screw kneads the material into a semi-solid, plasticized mass. If the food is heated above 100°C the process is known as extrusion cooking (or hot extrusion). Here, frictional heat and any additional heating that is used cause the temperature to rise rapidly. The food is then passed to the section of the barrel having the smallest flights, where pressure and shearing is further increased. Finally, it is forced through one or more restricted openings (dies) at the discharge end of the barrel as the food emerges under pressure from the die, it expands to the final shape and cools rapidly as moisture is flashed off as steam. A variety of shapes, including rods, spheres, doughnuts, tubes, strips, squirls or shells can be formed. Typical products include a wide variety of low density, expanded snack foods and ready-to-eat (RTE) puffed cereals. Cold extrusion, in which the temperature of the food remains at ambient is used to mix and shape foods such as pasta and meat products. Low pressure extrusion, at temperatures below 100°C, is used to produce, for example, liquorice, fish pastes, surimi and pet foods.



## **Working Principle**

In this process, plastic material in the form of pellets or granules is gravity fed from a top mounted hopper into the barrel. Additives such as colorants and ultraviolet inhibitors (liquid or pellet form) can be mixed in the hopper. The plastic material enters through the feed throat and comes into contact with the rotating screw. The rotating screw pushes the plastic beads forward into the barrel. The barrel is heated using the heating elements up to the melting temperature of the plastic. The heating elements are used in such ways that gradually increase the temperature of the barrel from the rear to the front.

There are three possible zones in a rotating screw i.e. feed zone, melting zone, and metering zone. In the feed zone, the plastic beads melt gradually as they are pushed through the barrel.

The plastic material is completely melted in the melting zone. A thermostat is used to maintain the inside temperature of the barrel. The overheating of plastics should be minimized which may cause degradation in the material properties. A cooling fan or water cooling system is used to maintain the temperature of the barrel during the process.

At the front of the barrel, the molten plastic leaves the screw and travels through a screen pack to remove any contaminants in the molten plastic. The screens are reinforced by a breaker plate.

The breaker plate assembly also serves to create back pressure in the barrel. The back pressure gives uniform melting and proper mixing of the molten plastic material into the barrel. After passing through the breaker plate, molten plastic enters into die. The die gives the desired shape of plastic product. An uneven flow of molten plastic would produce unwanted stresses in the plastic product. These stresses can cause warping after solidification of molten plastic. Plastics are very good thermal insulators and therefore it is very difficult to cool quickly. The plastic product is cooled by pulling through a set of cooling rolls.

## **Extrusion Process Parameters**

There are five important process parameters to be considered before extrusion process:

- Melting temperature of plastic
- Speed of the screw
- Extrusion pressure required
- Types of die used
- Cooling medium

## What is Extruder?

Extruders are used to create a wide range of items, including plastic tubing, trims, seals, plastic sheets and rods. Extruder is the machine for producing more or less continuous lengths of plastic sections out of a selected type of plastic resin. There are a number of extrusion techniques available such as co-extrusion, offset extrusion, oriented extrusion, overcoat extrusion, cold extrusion, ram extrusion and much more.

The essential elements for a thermoplastic extruder are a tubular barrel, usually electrically heated; a revolving screw, ram or plunger within the barrel; a hopper at one end from which the material to be extruded is fed to the screw, ram or plunger; a die at the opposite end for shaping the extruded mass.

## Types

Extruders may be divided into two general types:

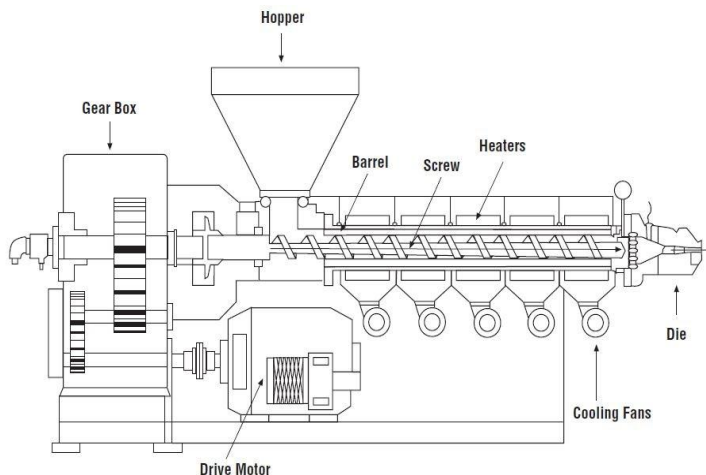
### 1. Single Screw Extruder

Single screw extruders are the most widely used extruders. The screw that is used to push the resin out of the die is the important component of a screw extruder. In the earlier days rubber screw were used but the rubber screw was not able to give enough amount of shear into the polymer. Therefore, screws were designed that would start deeper in the feed and gradually taper shallower in the metering section to apply more work on the polymer as it was going from the feed to the discharge.

Extrusion is a process used for creating a product (an extrudate) by forcing a material through a die or an orifice to form a shape, or alternatively an extruder is used to produce semi-finished or finished products.

This article mainly focuses on the extrusion of thermoplastic products due to their importance in extrusion processes. Undoubtedly, thermoplastics are the largest group of plastic materials extruded; almost 65% of all plastics pass through an extruder.

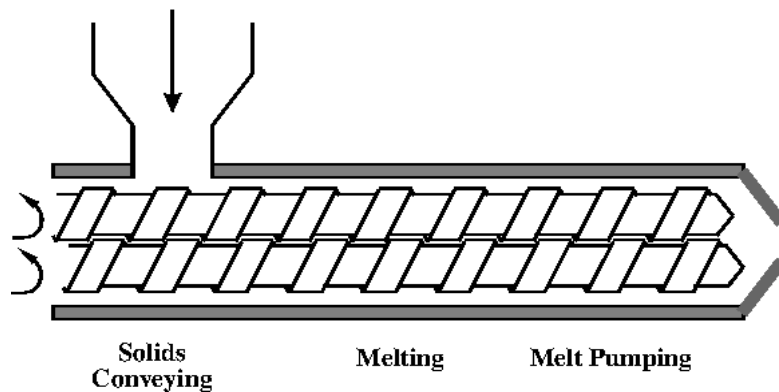
As the single screw machine is the most popular type of extruder, this article focuses on processes based on this type of machine. As single screw machines are relatively cheap, simple and easily provide a continuous output, they are very popular.



### 2. Twin or Multiple Screw Extruder

The screw is usually contained inside a tight fitting barrel driven by a variable speed motor and gearbox. It is a highly efficient device capable of processing several tons of plastic per hour, even in modestly sized extruders. The screw is divided into three division the feed section, the compressor and the metering section.

Twin screw extrusion is used extensively for mixing, compounding, or reacting polymeric materials. The flexibility of twin screw extrusion equipment allows this operation to be designed specifically for the formulation being processed. For example, the two screws may be corotating or counterrotating, intermeshing or nonintermeshing. In addition, the configurations of the screws themselves may be varied using forward conveying elements, reverse conveying elements, kneading blocks, and other designs in order to achieve particular mixing characteristics.



#### Components of an Extruder

A typical extruder usually consists of seven major components, such as: (1) feed assembly, (2) extruder barrel, (3) extruder screw, (4) extruder drive, (5) extrusion discharge or die system, (6) heating/cooling system, and (7) adequate safety and control facilities.